



SECTION 702

BEARING PILE

702.1 Description. This work shall consist of furnishing and driving concrete and steel piles to the bearing and penetration required, at the location shown on the plans.

702.2 Material.

702.2.1 All material shall be in accordance with Division 1000, Materials Details, and specifically as follows:

Item	Section/ Specification
Reinforcing Steel for Concrete	1036
Steel Strand	AASHTO M 203
Cast-In-Place Pile Shells (Thick Shell Type)	
Welded or Seamless Steel Pipe	ASTM A 252
Closure Plates	ASTM A 36
Fluted Pipe	SAE-1010 or SAE-1015
Forged Steel Tips or Noses	SAE-1020
Structural Steel Pile	ASTM A 36
Pile Point Reinforcement	ASTM A 27 Grade 65-35 (450-240) or ASTM A 148 Grade 90-60 (620-415)

702.2.2 Precast Concrete Piles. Precast concrete piles shall be manufactured of Class A-1 concrete to the shape and size shown on the plans or to an approved equivalent section. All material, proportioning, air-entraining, mixing, slump and transporting of concrete shall be in accordance with [Sec 501](#). Precast piles shall be straight, with a centerline variation of not more than 1/2 inch per 25-foot (1.6 mm/m) length of pile. Precast concrete piles shall be lifted and handled by a suitable bridle attached to the pile at points shown on the plans. Unless the concrete is steam cured in accordance with [Sec 703.3.17](#), removal of precast concrete from casting beds shall not begin for at least 48 hours after casting and not then until a compressive strength of 1500 pounds per square inch (10 MPa) has been attained. If the concrete is steam cured, removal shall not begin until a compressive strength of 1500 pounds per square inch (10 MPa) has been attained. Curing shall be continued for at least 24 hours after a compressive strength of 2400 pounds per square inch (17 MPa) has been attained. Precast piles shall not be transported or driven until at least 7 days after casting and then only if the compressive strength of 2400 pounds per square inch (17 MPa) has been attained. Compressive strength of concrete shall be determined by tests of standard cylinders made of concrete from the same batches and cured in the same manner as the piles.

702.2.3 Precast-Prestressed Concrete Piles. Precast-prestressed concrete piles may be furnished in lieu of precast concrete piles. They shall be manufactured in accordance with [Sec 705](#) using Class A-1 concrete. End anchors shall not be released until the concrete has attained a compressive strength of 4000 pounds per square inch (28 MPa) as determined by

tests of standard cylinders made of concrete from the same batches and cured in the same manner as the piles.

702.2.4 Cast-In-Place Concrete Piles. Cast-in-place concrete piles shall consist of Class B-1 concrete cast in pre-driven metal shells. The metal shells shall conform to the shape, size and minimum shell thickness shown on the plans, or to an approved equivalent section. All material, proportioning, air-entraining, mixing, slump and transporting of concrete shall be in accordance with [Sec 501](#). Metal shells driven with or without a core or mandrel shall be of sufficient thickness or shall be reinforced so that they will hold their original form without distortion after being driven. Metal pile shells shall be free from water, soil and other deleterious matter when concrete is cast in them. The contractor shall maintain on the job at all times prior to and during the filling of the shells, a light suitable for use in their inspection.

702.2.5 Structural Steel Piles. Structural steel piles shall be of the series rolled as H-bearing piles. They shall be of the size, weight and structural shape shown on the plans. Piles shall not have a camber or sweep in excess of 1/8 inch (10.4 mm) multiplied by the length of pile in feet (meters) divided by five. Steel piles shall be stored on platforms, skids or other supports at the site of the work and shall be supported at not more than 15-foot (4.5 m) intervals.

702.2.6 Pile Point Reinforcement. Pile point reinforcement shall be furnished and installed on structural steel piles at locations as shown on the plans and in accordance with [Sec 712](#) except as modified herein.

702.2.7 Pile Length. The pile lengths shown on the plans are approximate. The contractor shall be fully responsible for the lengths the contractor furnishes for driving to obtain the specified bearing and penetration. Sub-surface investigations made by the Commission are for design purposes only.

702.2.8 Test Piles. Test piles shall be the same material and size as the permanent piles. Test piles of precast concrete shall, in general, be driven in permanent position. Test piles shall be of such length as to permit driving the tips to an elevation 10 feet (3 m) below that indicated by plan lengths unless otherwise specified.

702.2.9 Certifications. For structural steel piles and thick shells for cast-in-place piles, the contractor shall furnish two copies of a certification from the pile manufacturer or fabricator setting out the designated specification with which the material furnished complies.

702.3 Equipment.

702.3.1 Concrete Testing Equipment. Equipment for field determination of compressive strength of concrete shall be furnished by the contractor at the location of manufacture of precast and precast-prestressed piles. The testing machine may be of any mechanical or hydraulic type capable of applying and measuring the required load and shall comply with the accuracy tolerances and corrections specified in AASHTO T 67, Section 16.1 and Section 17. Approximately the last one-half of the load shall be applied at a rate of between 1200 and 3000 pounds per square inch (8 and 21 MPa) per minute. The contractor shall furnish a sufficient number of compression test cylinder molds of a type meeting the approval of the engineer. The contractor shall furnish sufficient personnel for cleaning and preparing reusable molds.

702.3.2 Driving Equipment. The contractor shall furnish pile driving equipment adequate for handling the length of pile to be placed in the leads and for driving the total length of pile to the tip penetration and bearing required. Piles shall be driven with power-driven hammers, or by a combination of power-driven hammer and water jets. Power-driven hammers are defined as hammers operated by steam, air or diesel power. For determining the energy per

blow of diesel power hammers without a fully enclosed ram, 75 percent of the manufacturer's energy rating for the hammer will apply. If the contractor desires to check a diesel power hammer against an approved steam hammer on a specified type of pile at a particular site, the contractor may do so at no additional cost to the Commission, and the checked rating of the diesel powered hammer will be used in determination of pile bearing values at that site. Diesel hammers which have a fully enclosed ram shall be equipped with a gauge and accompanying charts which evaluate the equivalent manufacturer's rated energy being produced under any driving condition.

702.3.3 Leads. Pile driver leads shall be constructed in such manner as to afford freedom of movement of the hammer, and they shall be held in position by guys or stiffener braces to ensure support to the pile during driving. Inclined leads shall be used for the driving of battered piles.

702.3.4 Followers. Followers may be used in the driving of piles only if approved in writing by the engineer. If a follower is used, one pile of every group of ten shall be driven without a follower to determine the available bearing value of the group.

702.3.5 Water Jets. Water jets used to aid in driving piles shall be sufficient in number to deliver a volume and pressure of water at the jet nozzles that will freely erode the material adjacent to the pile. The use of water jets shall be discontinued before the final penetration is reached, and the piles shall be driven to secure a final penetration of not less than 2 feet (600 mm) if the nature of the soil permits.

702.3.6 Hammer Energy. The minimum energy developed by hammer per blow shall not be less than shown in Table I.

TABLE I	
Hammer Energy	
ENGLISH	
Type of Pile	Minimum Hammer Energy Required per blow, foot-pound (ft-lb)
Precast Concrete	1.0 ft-lb/lb times the total pile weight in pounds but not less than 8000 ft-lb.
Steel Shells for Cast-In-Place	3.0 ft-lb/lb times the total pile weight in pounds, including mandrel if used, but not less than 8000 ft-lb.
Structural Steel	The largest of the following: (1) 3.0 ft-lb/lb times the total pile weight in pounds. (2) 225 ft-lb/ton times the pile bearing value in tons. (3) 7000 ft-lb.
METRIC	
Type of Pile	Minimum Hammer Energy Required per blow, Newton-meter (N-m)
Precast Concrete	3.0 N-m/kg (mass) times the total pile mass in kilograms but not less than 11,000 N-m.

Steel Shells for Cast-In-Place	9.0 N-m/kg (mass) times the total pile mass in kilograms, including mandrel if used, but not less than 11,000 N-m.
Structural Steel	The largest of the following: (1) 9.0 N-m/kg (mass) times the total pile mass in kilograms. (2) 35.0 N-m/kN times the pile bearing value in kN. (3) 9500 N-m.

702.4 Construction Requirements.

702.4.1 The contractor shall furnish and drive test piles at locations specified. Where required, test piles shall be driven full length, or to refusal, or to a capacity 50 percent greater than that shown on the plans. In all cases the test piles shall be driven to not less than the minimum tip elevation shown on the plans for permanent piles. Test piles shall be driven with the same type of equipment as will be used for driving the permanent piles. Before driving test piles, the excavation shall be completed to an elevation not more than 2 feet (600 mm) above the proposed grade at the point where a test pile is to be driven. Test piles not driven in a permanent location shall be cut off, or pulled and backfilled, as approved by the engineer.

702.4.2 Foundation piles shall not be driven until after the excavation for the footing has been substantially completed. The heads of piles shall be protected against damage during driving. The procedure incident to the driving of piles, shall not subject them to excessive and undue abuse. Any pile broken or damaged by reason of internal defects or by improper driving, or driven out of its proper location shall be removed and replaced, or a second pile may be driven adjacent thereto if this can be done without detriment to the structure as determined by the engineer.

702.4.3 Where piles are to be driven through more than 5 feet (1.5 m) of compacted embankment, which has been in place for less than five years, prebored holes will be required entirely through the embankment to the lowest elevation of the natural ground line adjacent to the embankment, or as shown on the plans. The holes shall be of a diameter not less than that of the pile. The space remaining around any type pile after it is driven shall be completely filled with sand or other approved material.

702.4.3.1 Other locations where preboring for piles is required will be shown on the plans. At such locations, holes shall be prebored to the elevation specified prior to pile placement. The holes shall have a diameter not less than that of the pile and shall be large enough to avoid damage to the pile being driven through the hole in hard material. The size of the hole shall be approved by the engineer before preboring is started. Pilot holes of lesser diameter than the pile shall not extend below the pile tip. After the pile is placed in the hole and before driving begins, the space remaining around the pile shall be filled with sand or other approved material before and maintained full during the driving of the pile. The pile shall then be driven in accordance with the requirements of [Sec 702.4.11](#).

702.4.4 Final position of piles shall be not more than 1/4 inch per foot (20 mm/m) from the vertical or from the batter line shown on the plans. The maximum variation of the head of the pile from the position shown on the plans shall be not more than 2 inches (50 mm), except that piles in footings entirely below the finished ground line may not vary more than 6 inches (150 mm). All piles pushed up by the driving of adjacent piles, or by any other cause, shall be redriven to required bearing and penetration. Improperly driven, broken or otherwise defective shells shall be removed and replaced, or otherwise corrected to the satisfaction of the engineer.

702.4.5 Pile Point Reinforcement. Each point shall be made in one piece of cast steel with the minimum web and flange thickness equal to that portion of the pile being attached thereto multiplied by the factor (t) shown below.

Material	(t)
ASTM A27 Grade 65-35 (450-240)	2.0
ASTM A148 Grade 90-60 (620-415)	1.6

702.4.5.1 The point shall extend onto the pile a minimum of 1/2 inch (13 mm) for both faces of the web and for the end one-fourth of the inside face of each flange.

702.4.5.2 The web portion of the point shall protrude a minimum of 0.2 times the flange width below the pile with the flange portion transitioning to a protrusion of not less than its thickness at the extreme ends.

702.4.5.3 The point shall be attached to the pile with a full penetration weld along each flange. Weld backing shall be furnished for the total width of each flange, whether it be totally by point extension or combination of point extension and attached backing plate.

702.4.5.4 The point extension onto the web of the pile may be omitted if alternating 1 1/2 inch (39 mm) by 1/4 inch (7 mm) fillet welds are placed on each side of the web.

702.4.5.5 Welding of the point to the pile shall be by a welder certified by MoDOT. Properly dried low hydrogen electrodes of the E70XX series shall be used with adequate protection from the elements in accordance with [Sec 712.8](#). The contractor shall be fully responsible for the adequacy of welds during driving.

702.4.6 Splices. Extending and splicing of piles is not desirable and full length piles shall be driven wherever possible and practicable. The number of splices used shall be held to a minimum. If extensions and splices are permitted or required by the engineer, they shall be made as follows:

702.4.6.1 All welding, including splicing of steel shells and structural steel piles, and support or reinforcing angles welded to steel piles, shall be in accordance with [Sec 712.3.3.7](#) and performed by a MoDOT certified field welder using properly dried low-hydrogen E7018 electrodes that have been protected from the elements to maintain the dry condition. The contractor shall be fully responsible for the adequacy of welds during driving. Steel shells for cast-in-place concrete piles shall be spliced as shown on the plans. Structural steel piles shall be spliced with a butt joint as shown on the plans. The contractor will be permitted to furnish lengths of cast-in-place pile shells which incorporate not more than one splice per pile or structural steel piles which incorporate not more than one splice per pile for lengths up to and including 40 feet (12 m). Not more than two splices will be permitted in each structural steel pile furnished for lengths exceeding 40 feet (12 m). In preparation of piles prior to driving, the use of individual sections less than 8 feet (2.5 m) long will not be permitted. Additional field splices necessary to extend structural steel piles or cast-in-place pile shells to reach adequate bearing material shall be limited to one per pile, unless authorized by the engineer.

702.4.6.2 Precast and precast-prestressed concrete piles driven below plan elevations shall be extended by build-up construction. The forms for extensions of concrete piles shall remain in place at least 24 hours. The extension shall be cured in accordance with [Sec 703.3.17](#) and the exposed surfaces shall be finished in accordance with [Sec 703.3.15](#).

702.4.7 Cut-Offs. Tops of all piles shall be cut off square at cut-off elevations.

702.4.8 Protective Coatings. Before the coatings are applied, the steel shall be thoroughly cleaned. Steel shells and structural steel piles in end bents shall be coated with a heavy coating of an approved bituminous paint applied for a length of 3 feet (1 m) below the bottom of the concrete cap. All exposed steel piles shall be coated with bituminous paint 3 feet (1 m) below and one foot (300 mm) above the finished ground line. All other exposed surfaces of steel shells and structural steel piles, including bracing, shall be painted in accordance with [Sec 712.12](#) using System G, if there is no pay item for paint included in the contract; and the specified system if the contract contains a pay item for paint. Protective coatings below the normal low water line will not be required.

702.4.9 Concrete footings shall not be placed on cast-in-place piles until at least 12 hours after the last pile in the footing has been cast. No piling shall be driven within a radius of 20 feet (6 m) of concrete that has taken initial set and has not attained a compressive strength of at least 1500 pounds per square inch (10 MPa). Compressive strength will be determined by tests made in accordance with MoDOT methods.

702.4.10 Static Load Tests. The bearing value of piles shall be determined by actual load tests if specified or ordered by the engineer. The test shall consist of the application of a load placed upon a suitable platform supported by the pile, with suitable apparatus for accurately measuring the test load and the settlement of the pile under each increment of load. Hydraulic jacks with suitable yokes and pressure gauges may be used in lieu of the loaded platform. The test load shall be applied to exert a uniform pressure over the pile being tested. Prior to the driving of the pile to be loaded, the contractor shall submit to the engineer plans for applying the test load. Sketches showing arrangement of apparatus for obtaining settlements and recovery measurements of the test shall also be furnished to the engineer. Two gauges shall be used to measure settlement and recovery of the pile loaded, and at least one gauge shall be used on each hold-down pile to measure uplift if the hold-down system of load application is used. All test loads shall be applied concentrically and shall be kept uniform by constant attention to load gauge readings and jacking applications. The driven pile shall not be disturbed for at least 24 hours prior to the application of any portion of the test load. The load shall be applied in 25 percent increments of the total load, allowing rest periods of six, twelve and six hours respectively between the increment of loading. The safe allowable load per pile shall be considered as 50 percent of that load which, after remaining in place for 48 hours, produces a permanent settlement not greater than 1/4 inch (6 mm), measured at the top of the pile. All test loads shall be removed at 30 minute intervals in the same increments specified for placing, and readings for recovery shall be taken just prior to the removal of each increment. If results of the load tests are not satisfactory, the engineer will make arrangements for such corrective changes as deemed necessary which may include redesign of the foundations. No compensation will be allowed for any delay or inconvenience caused by corrective changes or redesign.

702.4.11 Dynamic Bearing Formulas. The following formulas will be used as a guide to determine the safe bearing value of piles if static load tests are not required.

ENGLISH		
$P = \frac{2WH}{(S+0.1)}$	$\cdot \frac{2W}{(W+w)}$	*for single acting hammers.
$P = \frac{2E}{(S+0.1)}$	$\cdot \frac{2W}{(W+w)}$	*for double acting hammers and diesel powered hammers with enclosed rams and bounce pressure gauges.
$P = \frac{2(0.75E)}{(S+0.1)}$	$\cdot \frac{2W}{(W+w)}$	*for all other diesel powered hammers unless tested as specified in Sec 702.3.2 .

METRIC		
$P = \frac{1636WH}{(S+2.54)} \cdot \frac{2W}{(W+w)}$.	$\frac{2W}{(W+w)}$ *for single acting hammers.
$P = \frac{167E}{(S+2.54)} \cdot \frac{2W}{(W+w)}$.	$\frac{2W}{(W+w)}$ *for double acting hammers and diesel powered hammers with enclosed rams and bounce pressure gauges.
$P = \frac{167(0.75E)}{(S+2.54)} \cdot \frac{2W}{(W+w)}$.	$\frac{2W}{(W+w)}$ *for all other diesel powered hammers unless tested as specified in Sec 702.3.2 .

*The value of $\frac{2W}{(W+w)}$ shall be considered unity if it exceeds one.

P	=	safe allowable bearing value in pounds (newtons).
W	=	weight (mass) of striking part of hammer in pounds (kilograms).
w	=	weight (mass) of pile and mandrel in pounds (kilograms).
H	=	height of fall in feet (meters).
E	=	manufacturer's rated energy in foot-pounds (joules) per blow at manufacturer's rated speed, or in case of a diesel hammer equipped with a bounce pressure gauge the actual energy shown by the gauge chart.
S	=	average penetration in inches (mm) per blow for 10 to 20 consecutive blows.

702.4.11.1 The above formulas are applicable only if:

- (a) The piles are driven in a vertical position.
- (b) The hammer has an unrestricted fall.
- (c) The pile head is not broomed, crushed or splintered.
- (d) There is no appreciable bounce of the hammer after striking the pile.
- (e) The penetration is at a uniform or uniformly decreasing rate.

702.4.11.2 For piles driven to a batter, the safe bearing value of the pile shall be taken as follows:

$$P_B = \frac{0.1(10-m)}{(1+m^2)} \times P$$

P_B	=	safe allowable bearing value in pounds (newtons) for batter pile.
m	=	the tangent of the angle of batter.
P	=	safe allowable bearing value in pounds (newtons) for vertical pile.

702.4.12 Piles shall be driven to the minimum penetration indicated on the plans. If no minimum penetration is shown on the plans, piles shall have a tip elevation at least 10 feet (3 m) below the bottom of the supported footing or 10 feet (3 m) below the natural ground line, whichever is lower, unless specifically authorized otherwise by the engineer. Piles other than structural steel piles shall be driven to attain a bearing value not less than that shown on the plans, determined in accordance with [Sec 702.4.10](#). Structural steel piles shall in general be driven to practical refusal which is defined as a pile bearing value of 1.9 times the design bearing value. In general, concrete piles shall not be driven to a bearing value in excess of 10 tons (90 kN) over the design bearing value.

702.5 Method of Measurement.

702.5.1 Piles in place shall be the actual length of all piles, except test piles, measured to the nearest foot (0.5 m) for that portion of each pile that remains permanently in the structure.

702.5.2 Test piles will be measured to the nearest linear foot (0.5 m) of pile authorized and driven.

702.5.3 Precast and precast-prestressed concrete piles with built-up extensions will be considered single piles for measurement. No measurement will be made for the length of pile destroyed when making the extension.

702.5.4 No measurement will be made for that excavation required to apply protective coatings. Measurement of prebored holes required under the provisions of [Sec 702.4.3](#) will be made to the nearest linear foot (0.5 m) of each hole specified or directed by the engineer. Final measurement will not be made except for authorized changes during construction, or where appreciable errors are found in the contract quantity. The revision or correction will be computed and added to or deducted from the contract quantity.

702.5.5 Pile point reinforcement will be measured per each and shall include all material, equipment, labor and any other incidental work necessary to complete this work in accordance with [Sec 702.4.5](#).

702.6 Basis of Payment.

702.6.1 The accepted quantity of bearing pile will be paid for at the unit price for each of the pay items included in the contract. No direct payment will be made for incidental items necessary to complete the work unless specifically provided as a pay item in the contract. No direct payment will be made for painting exposed surfaces of steel shells, structural steel piles and bracing.

702.6.2 Test piles will be paid for at the contract unit price. Test piles if driven and used as permanent piles in place will be paid for as test piles and not as piles in place.

702.6.3 No payment will be made for any cut-offs.

702.6.4 Loading test will be paid for at the contract unit price. Piles tested will be paid for as accepted bearing pile.

702.6.5 Pile point reinforcement, where specified, will be paid for at the contract unit price per each.

702.6.6 Payment for preboring as specified in [Sec 702.4.3](#) will be made at the contract unit price. No direct payment will be made for backfilling.

702.6.7 If a splice is authorized to extend a structural steel or steel shell pile to reach adequate bearing material, the only splices that will be paid for are those required to extend the pile after plan length plus 10 percent has been driven. Splices, if authorized, will be paid for as an additional 8 feet (2.5 m) of pile in place at the contract unit price.